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REQUIREMENTS AND DESIGN PARAMETERS FOR LODGEPOLE PINE STRIP-THINNING EQUIPMENT IN BRITISH COLUMBIA

BY
I.B. HEDIN, R.P.F.

Contractor: Forest Engineering Research Institute of Canada
201-2112 West Broadway
Vancouver, B.C.

Departmental Representative:

G.H. Manning
Pacific & Yukon Region
506 W. Burnside Road
Victoria, B.C. V8Z 1M5

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ABSTRACT

The characteristics of lodgepole-pine stands suitable for mechanical strip thinning are defined within two stand types. Ranges of age, density, diameter, and height are given. For each stand type, treatable hectares (within reasonable accessibility) in British Columbia are estimated, and recommendations for equipment requirements are presented.

PREFACE

The information in this report was obtained from a wide variety of sources, both through formal discussion and informal exchanges of opinions and experiences over the past several years. Although the specific project involved a six-month period, activities before and after the term have been drawn upon. Ministry of Forests and Lands personnel at Branch, Forest Region, and Forest District levels gave willingly of their time to discuss strip-thinning and stand-tending activities. The project addressed Timber Supply Areas, primarily because of the tenure responsibilities current at the time of initiation.

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SUMMARY

In British Columbia, lodgepole pine establishes in very dense stands following wildfires or other major disturbances. Physically reducing the density, handling downed snags, and clearing away cut stems are problems in these stands. Where large blocks with high densities require thinning treatment, mechanical methods may be more cost-effective than motor-manual methods. The project described in this report arose from a joint interest by the Forest Engineering Research Institute of Canada (FERIC) and the Canadian Forestry Service (CFS), in determining the potential for developing or modifying a machine for mechanical thinning. Funding was provided through the Canada/British Columbia Forest Resource Development Agreement (FRDA). The objectives of the project were: to prepare descriptions of lodgpeole-pine stands suitable for mechanical strip thinning, to determine the areas of these stands available for treatment, and to prepare a list of specifications for cutting attachments and carriers suitable for carrying out these treatments.

At the request of its membership, FERIC has monitored mechanical strip-thinning trials and requirements since 1981. To date, neither a machine nor a method for mechanical strip thinning has been found that meets the operational, economic, and biological requirements of industry or agency silviculturists. The biological constraints are: ingress and low live limb development in very young stands, age and density effects on crown and height development, and the ability and response rate of the crop trees. The latter two points influence the timing of treatment and therefore the size of stems severed. Repression (stagnation) is a characteristic of overstocked lodgepole-pine stands; height growth, as well as diameter growth and crown development are severely repressed in overstocked stands. Priorities for thinning young stands (less than 20 years) with good accessibility can be easily established. Unfortunately, the cost and yield trade-offs between thin/rehabilitate/leave in older stands have not yet been fully analyzed.

Two age/density types of lodgepole pine were defined as suitable for mechanical strip thinning. Type 1 is composed of stands 10 through 25 years of age. A minimum density of 10 000 to 20 000 stems/ha is necessary to ensure well-spaced stems remain after both strip and selective thinning have been done. At age 10 years, stands may be 10 000 to 100 000 stems/ha, 2 to 6 cm in diameter and up to 3 m in height. At ages 10 to 20 years, stand densities of 10 000 to 40 000 stems/ha will respond. These trees will be 2 to 12 cm in diameter, and trees of 8 to 12 cm in diameter will be common at age 20 to 25 years; heights will be up to 7 m.

The older type, Type 2, is composed of stands 40 to 80 years, with densities 3 000 to 6 000 stems/ha. These stands are considered priorities for thinning because timber supply shortages within Timber Supply Areas can be reduced if operability can be achieved within 20 to 40 years. Stand diameters range from 6 to 20 cm, and height from 7 to 15 m.

Information available on immature stands does not include details about density levels and suitability for treatment. Silviculture history records provide good information on age and densities, but are available only

for surveyed areas. Therefore, visits with Ministry of Forests and Lands foresters in regions and districts, and field visits to representative stands were used to provide estimates and to check the definition of the target stands. Areas within these two stand types, treatable by mechanical methods, and with reasonable accessibility and stand conditions (low insect and pathogen infestations with good response potential), were included in these estimates.

Stands with the target characteristics were established primarily following wildfire or excessive site preparation. Present logging, site-preparation, and regeneration practices generally do not result in densities greater than 10 000 stems/ha. Within the province, detailed information on large areas of fire-origin lodgepole pine is not available. They are often inaccessible, far from mills, and severely repressed or diseased. Estimates of 16 600 to 25 400 ha for Type 1 stands and 22 000 to 23 000 ha for Type 2 stands were determined.

The relatively small area defined as suitable for mechanical strip thinning does not have an equipment requirement that will attract manufacturers' interest. Therefore, development or modification of attachments mounted on existing carriers is the likely approach. To undertake mechanical strip thinning in Type 1 stands, it is recommended that a vertical shaft, rotary cutting head be purchased and modifications made. The cutter can be attached to a crawler or skidder carrier and field tests undertaken to establish whether the unit can meet the cost and biological goals. These stands should be treatable for less than $300/ha for the strip-thinning pass.

To carry out mechanical strip thinning in Type 2 stands, utilization of at least some of the cut stems is desirable. Shear, rim-driven circular-saw, or scissor-type cutters are more energy efficient and require less power than other designs. Small European carriers would be suitable for working in these stands. It is recommended for these stands that a used, small-size feller forwarder be purchased and modified with Canadian attachments. Field tests should be undertaken to establish biological and cost results. Costs would be roughly $400/ha, without accounting for offsetting revenue for thinnings.

INTRODUCTION

The regulation of stand density to meet forest-management objectives is an important silvicultural activity. Precommercial thinning using motor-manual methods can be prohibitively expensive under some conditions, for example in areas with steep slopes, heavy slash, or poor access. When large blocks with high densities require treatment, mechanical methods may be more cost effective. The feasibility of using mechanical thinning methods in lodgepole pine (Pinus contorta var. latifolia[1]) has been discussed for many years. Trials of mechanical methods have taken place and cost effectiveness has varied from reasonable to unacceptable. Uncertainties about growth response continue. Consequently, the industry is still discussing mechanical strip thinning. A successful machine or method has not emerged, and it has not been established where the growth benefits outweigh the costs of treatment.

The project discussed in this report arose from a joint interest in mechanical thinning by the Forest Engineering Research Institute of Canada (FERIC) and the Canadian Forestry Service (CFS). At the request of its membership, FERIC has monitored mechanical strip-thinning trials and requirements since 1981. Because no equipment is currently considered directly suitable for the treatment, the potential for developing or modifying such a machine in Canada is of direct interest to the CFS. Funding was therefore provided through the Canada/British Columbia Forest Resource Development Agreement (FRDA) to describe potential requirements for mechanical thinning and equipment.

The specific objectives of the project were:

- to prepare descriptions of lodgepole-pine stands suitable for mechanical strip thinning,
- to determine the areas of these stands available for treatment, and
- to prepare a list of specifications for cutting attachments and carriers suitable for carrying out these treatments.

Background information on previous mechanical strip-thinning attempts, the varied biological concerns, and the lack of quality information on the amount of stands suitable for mechanical thinning is important in order to understand the problems encountered in this project and to interpret the results. This background information is described first, followed by the results of the study.

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[1]Meidinger, Del. 1987. Recommended vernacular names for common plants of British Columbia. Draft report, B.C. Min. For. and Lands, Res. Br. 101 p.

PREVIOUS MECHANICAL STRIP-THINNING ATTEMPTS: BACKGROUND

In Western Canada, lodgepole pine establishes in very dense stands following wildfires or other major disturbances. Treating these stands is difficult, not only in physically reducing the density, but also in handling downed snags, in clearing away thinned stems, and in dealing with demanding and variable biological constraints. Previous mechanical strip-thinning trials in British Columbia, Alberta, and the western United States have shown that achieving good results at an acceptable cost is difficult (Crossley 1952; Lotan 1967; Bella 1972 and 1974; Bella and de Franceschi 1977 and 1982; Glen[2]; Herring[3]; Perry[4]).

Bella and Franceschi (1977) developed recommendations for treatments in overstocked lodgepole- and jack-pine stands in Alberta and Manitoba using mechanical strip treatments as a first pass. These included:

- only uniformly overdense stands should be treated,
- these stands should be strip thinned between five and ten years of age, and
- selective thinning should be done along the edges of the strips within five years.

It has been established that strip thinning alone does not produce an adequate growth response; follow-up selective thinning must also be done to provide release. With this realization, the economics of strip thinning is less attractive and the correct selection of stands for treatment becomes more significant.

FERIC's Western Division held a meeting with and canvassed member-company and Ministry foresters in 1985 to determine which lodgepole-pine stands could be treated by strip thinning. The results were summarized in Technical Note TN-89 (Hedin 1986). The descriptions within that Note were broad and reflected a diversity of opinion. However, the report categorized two stand types: less than 20 years in age and up to 60 years. Subsequent strip-thinning trials monitored by FERIC resulted in the publication of Technical Note TN-112 (Hedin 1987). These trials indicated some progress had been made in attaining operational success but an economical solution to strip thinning had not yet been reached.

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[2]Glen, Laughlan M. 1976. Spacing lodgepole pine with a Hydro-ax. Paper presented at C.I.F. Juvenile Spacing Workshop, Nanaimo, B.C. Unpublished. 21 p.

[3]Herring, L.J. 1981. Man vs. machine. B.C. Ministry of Forests, Prince George Forest Region, Report No. 3. 15 p.

[4]Perry, J. 1986. Strip thinning in juvenile lodgepole pine using the Brush Hog. B.C. Ministry of Forests, Cariboo Forest Region. Unpublished report. 14 p.

It can be concluded that, to date, neither a machine nor a method for mechanical strip thinning has been found that meets the operational, economic, and biological requirements of industry or agency silviculturists.

BIOLOGICAL CONSIDERATIONS IN THINNING LODGEPOLE PINE: BACKGROUND

The biological response of a stand to thinning depends on the stand's density, age, crown condition, site quality, and stem vigour. Unlike most species, lodgepole-pine's height growth is affected when stand density is very high. This means very dense stands produce very little volume increment. The physiology of "stagnation" or "repression" is just beginning to be understood.

Goudie[5] and Mitchell[6] determined through their work in the late 1970s that stands under severe repression continue to add height but at a low rate. As well, some crown differentiation occurs. Repression is often difficult to diagnose because poor height growth can also be attributed to age or poor site conditions. Goudie and Mitchell originally thought that repression in height growth began at a 2- to 3-m height and at densities greater than 50 000 stems/ha. The 50 000 stems/ha figure is now thought conservative and stands may be affected at lower densities. To reduce the possibility of repression, free-growing is now defined by the MOFL as maximum 5 000 to 10 000 stems/ha.

If repression begins at 2- to 3-m height at high densities, then trees which are 10 years old will be affected. At higher densities and older ages, the tree's ability to respond to the thinning treatment and the speed of growth response decrease. Determining when stands can be thinned successfully is very difficult and it is a task which still requires refinement.

In some overstocked areas, stands with very low productivity are extensive. Much of these areas have been eliminated from the productive forest land contributing to the province's annual-allowable-cut determination. The Forest and Range Resource Analysis classifies stagnant stands as "immature timber growing very densely .... not expected to become merchantable without major intervention such as juvenile spacing or, in severe cases, total elimination and renewal by planting" (Ministry of Forests 1984: C4). Estimates are presented in Table 1 for the occurrence of stagnant stands in British Columbia. Overstocking also occurs in dry-belt Douglas-fir, hemlock, and true-fir stands. The large area involved, 2 000 000 ha, is substantial. Details on the composition of these stagnant stands and the potential for rehabilitation by spacing or clearing are not available. FRDA-funded studies to classify some of these areas are currently underway.

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[5]Goudie, James W. 1980. The effects of density on the growth and development of repressed lodgepole pine and suppressed inland Douglas-fir. Final Rep. Contract Res. Proj. EP 850.02. B.C. Min. For., Res. Br. 31 p.

[6]Mitchell, K. J. 1980. Stagnant lodgepole pine. Proc. Res. Br. Act. Mtg., March 4-5, 1980, Victoria. Vol. 2, Silviculture. B.C. Min. For. 31 p.

The need to carefully balance response, timing, cost, and final product value when carrying out mechanical strip thinning has generated a diversity of opinions and relatively fixed positions. These range from advocating no treatment to developing structured priority-rating systems. Priority for treatment, regardless of the techniques used, is outlined in the B.C. Ministry of Forests and Lands Silviculture Manual. However, the Ministry is currently revising its guidelines for juvenile spacing in lodgepole pine. Indications are that prescribed density levels for priority treatment and subsequent selective thinning will be changed[7].

It can be concluded that the upper limit of age and density for mechanical strip thinning is not clearly defined by Ministry or industry policy. Priorities for young stands (less than 20 years old) with good accessibility can easily be established. However, the trade-offs between thin/rehabilitate/leave in older stands are less evident.

TABLE 1. Stagnant Stands on Crown Land: All Species and Sites (December 31, 1983) (Adapted from Ministry of Forests 1984)

Region	Hectares	Percent of Provincial Total
Cariboo	812 951	40
Kamloops	422 562	21
Nelson	84 896	4
Prince George	398 729	20
Prince Rupert	211 543	10
Vancouver	111 614	5
TOTAL (rounded)	2 042 300	100

SOURCES OF INFORMATION ON JUVENILE STANDS: BACKGROUND

The available information about age, density, and stand condition of juvenile stands is not complete. In most cases, past assessments have been limited to "stocked" or "not-stocked" classifications. In the past ten years, surveys have included more detailed information and this may in time lead to improved juvenile-stand data. For the moment, however, it is difficult to obtain details and researchers must work with fragmented information.

The primary sources of information on the area and condition of stands requiring treatment are the Inventory Branch data and the Silviculture

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[7]Paul Diggle, pers. comm., Silv. Br., B.C. Min. For. and Lands, December 1987.

Branch history and stand-tending records of the B.C. Ministry of Forests and Lands (BCMOFL), as well as estimates provided by local foresters.

A. Inventory Branch

The Inventory Branch collects and provides information on area by age class, species group, height class, crown closure, and site quality. Crown closure gives a measure of density but little differentation is made between stocked and overstocked stands. The areas included are best-estimates for the last inventory update and are meant specifically for inventory use. Areas within the stagnation estimates in Table 1 may be excluded from inventory figures because they do not contribute to the annual allowable cut. Consequently, developing a "fudge factor" to estimate overstocked but recoverable stands was determined to be without value and Inventory Branch information was not usable.

B. Silviculture Branch

History and stand-tending records of the Silviculture Branch contain details about activities undertaken on recently established stands and surveys on disturbed sites and immature stands. The completeness of this information, however, depends upon the number of surveys accomplished and whether this information is made available through the system.

1. Denudation

The history records maintained by the Silviculture Branch provide data on area and causes of denudation. Table 2 outlines denudation by Timber Supply Area (TSA), based on the 1977 to 1986 figures of areas with lodgepole pine as the leading species prior to denudation. "Other" includes wildfire, insects and disease, and windthrow. The table shows that TSAs with the largest areas of lodgepole pine logged each year are Prince George and Williams Lake each with over 6 000 ha/year.

Logging denudation is generally constant from year to year for each TSA and will increase or decrease only with major changes within the industry or resource base. In most cases, very high "Other" figures reflect a single year or several years with catastrophic events. For example, in 1982, 39 388 ha of lodgepole pine were burned in the Fort Nelson TSA, resulting in the high 10-year average.

2. Stand-Density Records

The data available for age, species, and density of surveyed stands are excellent, where such sampling has occurred. Juvenile stands are sampled according to priorities for treatment or a specific objective. Therefore, stands with higher densities may not have been surveyed in the proportion they occur. Instead, reconnaissance surveys note broader descriptions. Information on these more difficult stands is very limited. The records were referred to during the study as a check, but were not used because of the gaps of information at higher densities.

TABLE 2. Denudation of Timber Supply Areas (1977-1986)
(From History Records, Silviculture Branch, MOFL.)

Timber Supply Area	Average Denudation by Logging (ha/yr)	Average Denudation by Other Means (ha/yr)	Average Total Denudation (ha/yr)
1. Arrow	266	56	322
2. Boundary	1 058	140	1 198
3. Buckley	794	50	844
5. Cranbrook	1 097	682	1 779
6. Peace	1 411	1 753	3 164
7. Golden	533	80	613
8. Fort Nelson	0	4 106	4 106
9. Invermere	399	1 605	2 004
10. Kalum	127	1	128
11. Kamloops	1 574	192	1 776
12. Kispiox	456	27	483
13. Kootenay Lake	193	37	230
14. Lakes	3 122	45	3 167
15. Lillooet	594	72	666
16. MacKenzie	3 392	483	3 875
17. McBride	209	76	285
18. Merritt	1 349	114	1 463
20. Morice	2 552	2 270	4 822
22. Okanagan	3 442	1 002	4 444
23. 100 Mile House	3 581	289	3 870
24. Prince George	7 616	816	8 432
26. Quesnel	4 581	346	4 927
29. Williams Lake	6 230	1 355	7 585
TOTAL	44 574	15 594	60 173

3. Stand-Tending Records

The Silviculture Branch stand-tending records include the activities for each year, as reported to the Branch. The information within these records is not complete and reporting often is delayed. Juvenile-spacing activity in the past has been low. Moreover, the results of major spacing programs in some areas in 1985, 1986, and 1987 have not been entered into the stand-tending data bank. Figures available from those records are much lower than known programs. Despite the paucity of data, discussions with Ministry personnel indicate that up to 2 000 ha of lodgepole pine and dry-belt Douglas-fir within each Interior Forest Region were spaced in 1985, with even more in some TSAs in 1986 and 1987.

TARGET STANDS FOR MECHANICAL STRIP THINNING

The descriptions of target stands for strip thinning in Technical Note TN-89 were checked for their applicability during this project. As each dense stand becomes older, its ranking on the priority list first increases

as it reaches an optimal condition for treatment, and then decreases until it reaches a point where it is considered a poorer investment.

During the fall of 1986 and spring of 1987, visits were made by FERIC personnel to 15 lodgepole-pine stands. These stands required thinning and most fell within mechanical-treatment guidelines, as defined in TN-89. Stands representative of those visited are shown and described in Figures A through F. When these visits were made, other stands, which fit loosely within the definition, were also viewed. The latter, judged to be incapable of responding to mechanical strip thinning, were not considered to be a priority for treatment because of repression or disease.

The target descriptions were defined more closely than in TN-89, although the concept of two age/density types was retained. Discussions during this project and in other situations have demonstrated there are "confidence zones" for thinning lodgepole pine. The areas of uncertainty produce differences in opinion about response, density levels, and treatment age. The two types of stands described here represent conditions where current knowledge and experience have demonstrated significant gains can be made by treatment. Many stands outside of these conditions (more severe in terms of overstocking and increasing age), currently carry risks greater than anticipated gains.

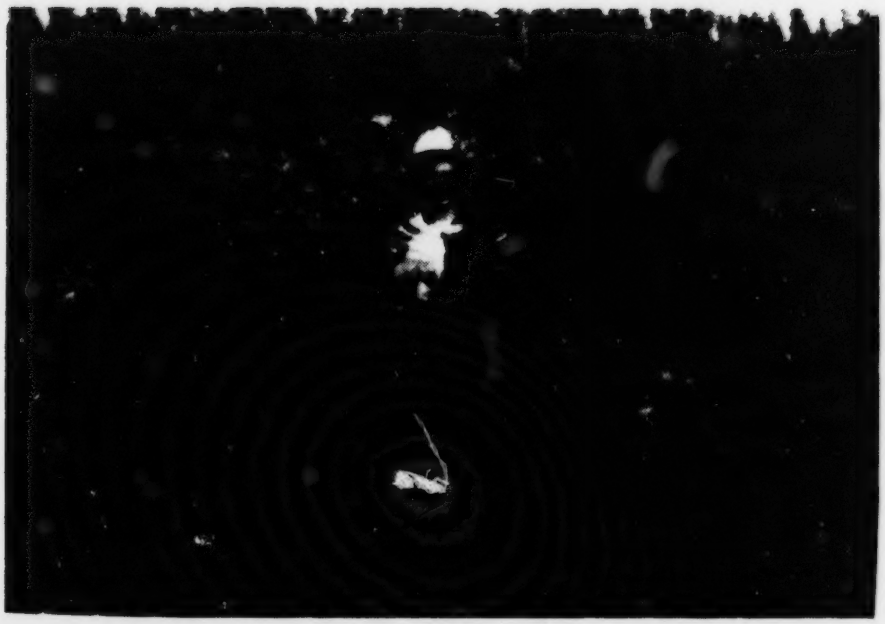

FIGURE A. Overstocked Lodgepole-Pine Stand in Williams Lake TSA.

This block had been logged and the regeneration is 5 to 10 years old. The clump shown here has a spot density of 100 000 stems/ha, although the overall density is less than 20 000 stems/ha. This portion of the stand will develop into an area similar to Figure B.

FIGURE B. Overstocked Lodgepole-Pine Stand in Prince George TSA.

This stand resulted from a 1960 wildfire. The stems shown are in a dense portion of the block, and are 80 000 stems/ha at this point. Overall density is 25 000 to 30 000 stems/ha. Diameter at ground level is 2 to 6 cm, with an average of 3 cm. Dominant height is 4 to 5 m. The maximum diameter of slash in this area is 20 cm, but the slash profile is up to 0.5 m in height. Live limb height is greater than 1 m in most cases. At the density shown in this photo, live crown was about 50 percent. Ground was generally flat with a 20 to 30% slope at the back of the block.

This stand is marginal for treatment as the age and density combination will have had a serious repression effect.

FIGURE C. Overstocked Lodgepole-Pine Stand in Kamloops TSA.

This stand is fire origin, about 20 years old. The density here is about 30 000 stems/ha. Diameter at ground level is 2 to 7 cm, with an average of 4 cm. Dominant height is 4 to 5 m. Live-limb height is greater than 1 m and live crown is generally greater than 50%. Slash diameter is up to 30 cm, with occasional accumulations up to 0.5 m. Surface rock is also present on the site. Slopes are 10 to 20%, with 30 to 40% into drainage channels.

The stand falls within the Type 1 characteristics. It should respond to treatment because the crown is still well-developed and the stand is healthy.

FIGURE D. Overstocked Lodgepole-Pine Stand in Okanagan TSA.

This stand is 35 years of age, and fire origin. Density is 15 000 to 20 000 stems/ha. Mortality is beginning to have an effect on the stand. Diameter ranges from 3 to 12 cm, and averages about 8 cm. Dominant height is 8 m. Live crown is less than 50%. Slash within the stand is up to 30 cm in diameter but is partially decomposed. Material from mortality in the stand is beginning to add to the slash loading.

This stand is intermediate between Type 1 and Type 2. The density is high, crowns are light, and the stems are spindly. If very small material was marketable as orchard material, for example, the area might benefit from a rehabilitation clearing.

FIGURE E. Overstocked Lodgepole-Pine Stand in Okanagan TSA.

The stand is 50 to 60 years old. Density is 4 000 to 6 000 stems/ha. Diameter ranges from 10 to 20 cm, and dominant height is about 14 m. Mortality within the stand has added debris, but generally slash levels are low. Slope is 10 to 20%.

A small-wood product might be removed from this stand to reduce time to final harvest.

FIGURE F. Overstocked Lodgepole-Pine Stand in Lakes TSA.

This stand is 60 years old and has 3 000 stems/ha. Stem diameters are up to 20 cm and average 12 cm. Dominant height is 15 m. Slope is flat to 10% and obstacles consist of downed material to 15 cm diameter. Some of this material is elevated to 0.5 m height.

A good product should be salvaged from a stand with these characteristics. With a 700 to 900 stems/ha leave density, response is expected to be good. This type of stand is included in "opportunity-wood" proposals within Prince George T.S.A.

A. Type 1 Stands: Young Lodgepole Pine

1. Age and Density

Early treatments are desirable to avert repression. However, ingress of seedlings, low-live-limb development, and lack of expression of dominance make thinning at a very young age inadvisable. Loss of volume growth, poor crown development, and slow response to thinning restrict the upper limit of thinning age, again depending upon the density encountered.

A minimum density of 10 000 to 20 000 stems/ha is necessary to ensure that well-spaced, good-quality stems remain after mechanical and follow-up selective thinning is completed (1 000 to 2 500 stems/ha). For strip-thinning treatments, clumpiness must be minimal at the lower densities or open areas can be accentuated with treatment.

Ages 10 through 20 years will respond well. For stand ages of 10 years, 10 000 to 100 000 stems/ha can be treated. Twenty- to 25-year-old stands will be reaching repressed states at the higher densities where crown development is severely restricted, but response is still expected at 10 000 to 40 000 stems/ha. By thirty years, lower density stands may be suitable for motor-manual methods; stands with densities suitable for strip thinning will have uncertain response. Densities over 30 000 stems/ha at this age may be candidates for rehabilitation programs.

2. Diameter and Height

The 10-year-old stand will have vigorous individuals with ground-level diameters of 6 cm. However, rate of growth will decrease rapidly at the densities described above for a stand of this age. An overall figure for these stands would be 2 to 6 cm, with individuals of 8 to 12 cm common at the older ages and lower ranges of the density spectrum. At early ages, height differences between individual stems can easily be several metres, due to age and vigour differences. Ten-year-old stands would be 1 m to a top height of roughly 3 m. With increasing age, this relative range in height appears to lessen somewhat and then dominance begins to be expressed and the difference returns. By 20 years, if the stand has not been seriously height-repressed, tree heights would range between 5 to 7 m, and up to 9 m at 30 years. More dense stands will have been affected more severely by competition and repression.

3. Low Live Limbs

Within a stand 10 years old, live limbs will be to ground level. By 15 years, live-limb height will average 10 to 15 cm height in stands of the required density. This level will increase until live-limb heights are 50 cm to 1 m from ground level.

4. Stand Condition

By definition, mechanical strip thinning is indiscriminant in the stems it removes. Therefore, stands must have large numbers of healthy

individuals. The BCMOFL has guidelines of a minimum of 1/3 live crown on leave trees for thinning treatments, with a priority on 70% or greater live crown. As well, disease- and insect-free stands, or those with light infestations (less than 15%), are rated more highly.

5. Slope and Ground Conditions

Although lodgepole-pine sites are generally on easy ground, some are not. Slope and obstacles can present real challenges for a prime mover. Slopes of 15 to 20% are common and the ability to traverse 30% would allow the majority of areas to be treated. Windfall obstacles must be overcome and slash/windfall material may be up to 0.5 m deep but more commonly is 0.2 to 0.3 m deep. The extreme slash profiles of greater than 1 m may simply be too difficult to treat. Soil texture and moisture conditions are generally not obstacles to treatment. A combination of slope, moisture, and slash depth can be a traction problem.

A summary of the main characteristics of treatable, juvenile lodgepole-pine stands is given in Table 3.

B. Type 2 Stands: Older Immature Lodgepole Pine

In some Timber Supply Areas, age-class structure is imbalanced and shortages of supply will occur within 10 to 20 years. One strategy for overcoming the projected shortages is to thin 40- to 80-year-old stands in order to achieve an operable stand within 20 to 40 years (Dahms 1971). Target stands are adding increment slowly in their present condition, and operability would not be achieved until age 120 to 160 years without treatment. Final density after treatment would be 600 to 1 000 stems/ha. Mechanical treatment in these stands would involve strip thinning of corridors and then selective removal of stems within leave strips.

1. Age and Density

Stands 40 to 80 years old, with densities 3 000 to 6 000 stems/ha, will respond well to treatment and provide a product from thinning. The merchantable component of these operations is attractive because it offsets the cost of treatment.

2. Diameter and Height

Diameters in these stands are within the 6 to 20 cm range, with averages of 10 to 12 cm. Heights range from 7 to 15 m.

3. Low Live Limbs

Live limbs below stump height are not a problem at stands of these ages and densities.

TABLE 3. Stands Suitable for Mechanical Strip Thinning: Summary of Characteristics

Characteristics	Type 1 Stands Young Lodgepole Pine	Type 2 Stands Older Immature Lodgepole Pine
Age and Density	a. 10 years minimum age at 10 000 to 100 000 stems per ha. b. 25 years at 10 000 to 40 000 stems per ha.	40 to 80 years old with densities of 3 000 to 6 000 stems per ha.
Diameter and Height	a. At 10 years, 2 to 6 cm diameter and 1 to 3 m height. b. At 25 years, diameters may be 8 to 12 cm and heights 5 to 7 m at lower densities. At higher densities, 2 to 6 cm diameters and 3 to 5 m height will be more common.	Range of diameter from 6 to 20 cm, with averages 10 to 12 cm. Height range 7 to 15 m.
Low Live Limbs	a. At 10 years age, many live limbs will be at ground level. By 15 years, average height of live limbs will have risen to 10 to 15 cm. By 25 years at 20 000 to 40 000 stems per ha, live limbs will be 0.5 to 1 m from the ground.	Well above stump levels.
Stand Condition	a. Stands should have healthy crowns (minimum 33%, preferred greater than 70%), and have low levels of disease or insect attack.	Insect or disease infestations are low or non-existant. Live crown greater than 33%.
Slope	a. Upper average slope of 15 to 20% with occasional 30% areas.	Less than 20% with most of the area below 10%.
Ground Roughness	a. Slash and windfall material will commonly be 0.2 to 0.3 m in height, with occasional 0.5 m material.	Range of conditions from no slash, to averages of 0.2 to 0.3 m in height with maximum 0.5 m.

4. Stand Cc dition

As with he younger stands, healthy trees with a full crown will respond more rapic y and will tolerate the changes in the canopy.

5. Slope ar Ground Conditions

Slope or these sites generally is below 20%. Usually in the time since establishmer , slash material will have rotted but in some dry climate

areas, sound slash material will remain. Windfall during the development of the stand may produce obstacles up to 0.5 m depth.

6. Other Factors

Snow breakage, a high risk of windthrow, insect populations, and fire hazard from high slash levels may affect the decision to treat and the timing of treatment.

A summary of the characteristics of older, immature lodgepole pine in stands suitable for mechanical thinning are presented in Table 3.

ESTIMATION OF TREATABLE AREA

The geographical spread of the TSAs with significant lodgepole-pine harvesting demonstrates the province-wide importance of the species and its management (Figure G).

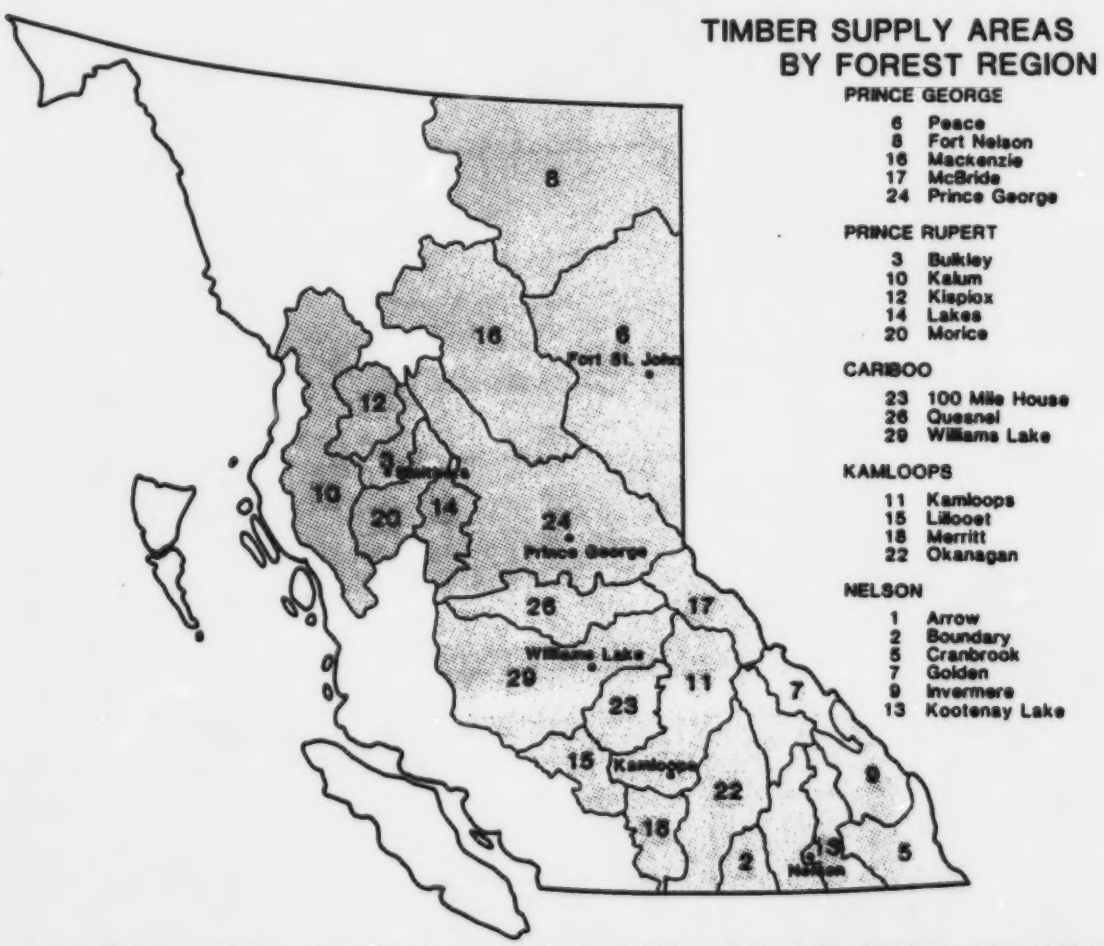

FIGURE G. Timber Supply Areas with Significant Lodgepole-Pine Harvesting.

During the fall of 1986 and spring of 1987, stand-tending foresters and silviculturists were canvassed for their opinions on the requirements for mechanical strip thinning in TSAs. During the same time period, over 15 sites were visited for field inspection. Based on what was learned during these discussions and field visits, several major conclusions have been made about the potential for mechanical strip thinning in British Columbia.

a. The majority of stands that fall within the density requirements for strip thinning are fire-origin.

b. Present logging and silvicultural practices often will not result in densities of greater than 10 000 stems/ha. Excessive site preparation, however, can easily achieve stocking levels higher than 10 000 stems/ha.

c. Large areas of fire-origin immature lodgepole pine have not been described accurately. Much is inaccessible or very far from manufacturing centres. Some stands are severely repressed and will not respond well to thinning. In addition, lodgepole pine is susceptible to many mammal and insect pests. Vast areas are infested with cankers, mistletoe, or bark beetles and are not good candidates for thinning investments. Many of the central and northern TSAs have areas in these conditions.

d. Some of the stands FERIC was referred to during the field visits were in the process of being motor-manually thinned by crews under various funding programs. The shift of funding from direct provincial silviculture budgets to federal-assisted projects has placed a stronger emphasis on labour-intensive work near manufacturing centres. This trend may result in fewer stands being available for mechanical thinning.

The estimates of area that are given in this section refer to the target stands described earlier. Accessibility and the conditions of each stand are important factors. The numbers of hectares are those that can be realistically thinned by mechanical means and within a somewhat flexible priority ranking. The figures have been arrived at through discussions and field visits.

A. Prince George Forest Region

1. Fort Nelson TSA

Little logging of lodgepole pine is currently taking place in the Fort Nelson TSA. Distance and low growth rates reduce the possibility of a large mechanical-thinning program.

2. Peace TSA

Disease infestation (gall rust and mistletoe) is very high and the benefits of treatment are minimal. At the current time, these stands do not fall within a high priority for treatment.

3. Mackenzie TSA

This TSA has fire-origin stands that fall within the criteria for mechanical strip thinning. However, distance to a manufacturing centre is beyond current, or even extended, guidelines. Within the southern part of the TSA, regeneration resulting from logging does not establish at the guideline densities.

4. McBride TSA

The lodgepole-pine component in McBride TSA is minor.

5. Prince George TSA

Fires within the TSA have generated areas suitable for mechanical strip thinning. In the Prince George East Forest District, 3 000 to 5 000 ha are suitable for strip thinning although this area is approaching severe repression levels. In the Prince George West Forest District, 1 500 ha of fire-origin pine fall within the guidelines established for strip thinning.

In Vanderhoof Forest District, 3 000 to 5 000 ha are suitable for strip thinning. However, where salvage logging was not done, slash and snag conditions make any thinning treatment very difficult.

In the Fort St. James portion of the TSA, strip thinning is not thought to be an option at this time for any of the stands. Suitable stands are not frequent and are relatively inaccessible.

B. Prince Rupert Forest Region

Prince Rupert Forest Region has timber-supply problems for several of its TSAs. Stands 20 to 80 years of age have been identified that will benefit from thinning and fertilization to improve sawlog content*. Within the next 10 years, 53 250 ha in Lakes TSA and 24 000 ha in Morice TSA are estimated treatable within 40 km of manufacturing centres. If 25% of these stands could be treated by mechanical thinning with utilization of the thinned material, then the potential for harvesting and utilization system development for small contractors is significant. Although current logging and silvicultural activity in Dease TSA is low, future developments in improving access may generate interest in coming years.

C. Cariboo Forest Region

1. Quesnel TSA

Fire-origin densities are moderate, with 30 000 stems/ha at the upper end. Two thousand to three thousand ha are estimated to be available for mechanical strip thinning within a reasonable distance from the mills.

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*Northwest Regional Public Affairs Committee. 1987. An intensive silviculture option for the Lakes and Morice T.S.A.s. Assoc. B.C. Prof. For., Paper for presentation to Minister of Forests, February 5, 1987.

2. Williams Lake TSA

The area has undergone many mechanical strip-thinning trials over the years and the terrain is good for using mobile equipment. According to the size, age, and density factors, and within a reasonable distance from the mills, 3 000 to 5 000 ha are suitable for strip thinning.

3. 100 Mile House TSA

Generally, stands in this TSA can be motor-manually thinned.

D. Kamloops Forest Region

1. Lillooet TSA

The Lillooet TSA does not have a large component of lodgepole pine. In addition, many of its stands are far from manufacturing centres and have not been considered a priority for treatment. This may change with reductions in allowable cut. Thinning of lodgepole pine and other species may become more important.

2. Kamloops TSA

The southern Kamloops TSA has a variety of ages and densities of immature lodgepole pine. Two to three thousand hectares can be targeted for treatment.

3. Merritt TSA

Density levels in the Merritt TSA generally do not fall within the requirements for mechanical strip thinning.

4. Okanagan TSA

The Okanagan TSA is extensive in area and includes three Forest Districts. Overall, 500 to 1 000 ha of younger lodgepole pine, and 2 000 to 3 000 of Type 2 stands can be treated using mechanical strip-thinning methods.

E. Nelson Forest Region

Kootenay Lake, Arrow, and Revelstoke TSAs within Nelson Forest Region have small lodgepole-pine components. Harvest within the species is relatively small.

1. Boundary TSA

The information about the Boundary TSA suggests it does not have significant mechanical strip-thinning requirements.

2. Cranbrook TSA

The Cranbrook TSA has been active in the past two years in strip thinning within its major fire area. An estimated 500 ha is available within the strip-thinning age and density levels.

3. Invermere TSA

This area has 200 to 500 ha suitable for strip thinning.

4. Golden TSA

The Golden TSA has Type 1 stands with an estimated 900 ha suitable for strip thinning. Approximately 1100 has of Type 2 are presently available for treatment.

A summary of the estimates of areas suitable for mechanical strip thinning is found in Table 4.

TABLE 4. Summary of Potential Strip-Thinning Areas by TSA and Forest Region (ha)*.

Timber Supply Area	Type 1 Stands	Type 2 Stands
Prince George Forest Region		
24 Prince George	7 500-11 500	
Prince Rupert Forest Region		
14 Lakes		13 000
20 Morice		6 000
Cariboo Region		
26 Quesnel	2 000-3 000	
29 Williams Lake	3 000-5 000	
Kamloops Forest Region		
11 Kamloops	2 000-3 000	
22 Okanagan	500-1 000	2 000-3 000
Nelson Forest Region		
5 Cranbrook	500	
9 Invermere	200-500	
7 Golden	900	1 100
TOTAL PROVINCE	16 600-25 400	22 100-23 100

* Estimates from discussions with MOFL personnel.

EQUIPMENT REQUIREMENTS FOR STRIP THINNING

Before discussing what is needed, it is valuable to reflect on what has been done in the past.

A. Available Equipment

Equipment currently available for mechanical strip thinning has been well summarized over the past 15 years by several researchers examining mechanical treatments (Dunsfield 1974; McKenzie and Miller 1978; McKenzie and Zarate 1984; Smith[9]). Work in the southeastern United States in the 1960s and early 1970s was done using Kershaw and Hydro-Ax equipment. A variety of other implements have been used on trials throughout North America, but have not achieved extensive operational use. In essence, these studies have shown mechanical strip thinning to be expensive and only attractive where treatable stands show an economic benefit. It is more attractive economically to harvest and treat stands so they do not require this treatment. However, mechanical thinning, combined with motor-manual selective thinning, makes economic sense given the projected shortfalls in timber availability and the backlog thinning situation in some areas of British Columbia.

In British Columbia, the Hydro-Ax 520 has met operational requirements (i.e. $250/ha) in two trials in the Cranbrook TSA. The cutting head was tested as the rubber-tired Hydro-Ax, and as the tracked, contractor-modified "Track-Ax" (Hedin 1987; Forrester[10]). Concept trials which involved mounting a cutting head on a boom attached to an FMC 220BG tracked skidder and then a Caterpillar 205 excavator, have also been carried out over the past five years but trial costs were operationally unattractive. A Caterpillar 205 is currently providing access trails in some treatments in the Cariboo. Strip-thinning trials with brush blades and Hydro-Ax equipment have also been done in the Lakes TSA.

A machine that might be considered a hybrid of the above equipment, the Canterra Brushcutter, has attracted interest throughout Canada but no real support from agencies or industry has developed. Although the machine had the advantages of narrow width, high power, and good maneuverability in both carrier and head, it has been sold to a contractor in the United States.

B. Proposed Approach to Designing Strip-Thinning Equipment

According to the estimates in Table 4, approximately 20 000 ha each of Type 1 and Type 2 stands meet the suitability requirements of various agencies and researchers for mechanical strip thinning. To remain suitable

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[9]Smith, C.R. 1987. Alternative methods for precommercial thinning balsam fir: potential and requirements. Paper presented at 68th Annual Meeting, Woodlands Section, Canadian Pulp and Paper Association, Montreal. 9 p.

[10]Forrester, P.D. 1987. Tracked front-end loader with rotary-ax attachment. For. Eng. Res. Inst. Can., Field Note in preparation. 2 p.

for mechanical strip thinning, they should be thinned within five years. Consequently, a mechanical thinning program to treat these stands would have to process 8 000 ha/year. If an effective working season of 1 400 hours and a standard treatment rate of 0.6 ha/hour are used, then this area can be processed by 10 machines.

A total of 10 machines is not a big fleet and unlikely to attract the interest of manufacturers. Even when pine areas in Alberta and Saskatchewan and balsam-fir areas in eastern Canada are considered, the likely population will not exceed 20 to 25 machines. Also, as later discussions will show, the machines needed for Type 1 and Type 2 stands will be different so the potential population of each style decreases. Given these factors, it is clear that designing a suitable cutting attachment for mounting on a carrier is the most feasible plan to pursue.

Although it is felt that the characteristics of the two types of stands are dissimilar enough to warrant a different approach to cutting the stems, both stands have one similar problem and that is the disposal of the severed stems. The significance of this problem, from a machine design point-of-view, should not be underestimated.

For the Type 1 stands, the main machine design problem is developing a cutting head that prevents the growth of low live limbs. This can be achieved by burying the head in the soil as it severs stems, or by cutting the stems in such a way that they are shattered. In both cases, head design would likely use rotary motion to achieve the cutting action. The rotary motion would cut up and then fling the stems. A relatively clear path would be left for the carrier to travel in, and for future access for selective thinning. Several cutting heads are currently available that, with minor modifications, could be used in this application. The proper mounting of the cutting attachment to the carrier, and the selection of a suitable carrier, would require some experimentation to ensure that the biological, productivity, and cost objectives are achieved. Use of a commonly available carrier would be financially attractive, particularly if the carrier could be used in other applications in the off-season.

For the Type 1 stands, it is recommended that a vertical shaft, rotary cutting head be purchased and modifications be made. The cutter can be attached to a crawler or skidder carrier and field tests undertaken to establish whether the unit can meet the cost and biological goals.

For the Type 2 stands, the main problems will be in cutting the stems in an energy-efficient manner and then disposing of them in a manner that permits forward motion of the carrier, as well as permitting future access and minimizing damage to the residual stand. Flail-type cutters are not efficient in stems approaching 10 cm in diameter and horsepower requirements escalate quickly. Shear, rim-driven circular-saw, or scissor-type cutters are much more energy efficient and require less power. They also permit accumulation and control of the severed stems. A carrier with a forwarding capability, as well as the ability to cut, accumulate, and place the trees, would be needed. The option of disposing of the stems within the stand as chips is not a viable option. Earlier attempts at this resulted in

heavy, expensive, high-horsepower, and relatively immobile machines. Carriers of the type and size suggested above would have to be acquired in Europe because the market potential does not justify the costs of developing one in Canada. However, the cutting attachment and mounting would be of Canadian design.

It is recommended that a used, small-size feller/forwarder be purchased and modified with Canadian attachments. Field tests should be undertaken to establish biological and cost results.

Approximate calculations indicate that the Type 1 stands could be mechanically strip thinned for less than $300/ha. Similar calculations indicate Type 2 stands would be more expensive ($400/ha) but there would be offsetting revenue if markets for products of thinning were developed.

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